PUBLIC HEALTH REPORTS

VOL. 35 DECEMBER 17, 1920 No. 51

AN EPIDEMIOLOGICAL STUDY OF AN ENDEMIC FOCUS OF LEPROSY.

By MARK F. BOYD, Passed Assistant Surgeon (Reserve), United States Public Health Service, in the laboratory of bacteriology and preventive medicine, medical department, University of Texas, and WARREN F. FOX, Passed Assistant Surgeon, United States Public Health Service.

Having learned of the prevalence of leprosy in the area under consideration to a degree unusual in the United States, it appeared advisable that all available data pertaining thereto should be secured and made a matter of record. This study was therefore undertaken in an unofficial capacity, a circumstance which possibly has not aided in the collection of information. For reasons that are obvious, an epidemiological investigation of a chronic disease of long duration, such as leprosy, is a much more difficult matter than the collection of similar data for an acute infection. The records of the health department are very meager, and relate only to the reports of cases within recent years. So far as possible, our information was secured from the patient himself, and where the patient himself was not available, for one reason or another, we are largely indebted to the practicing physicians of the city for our information. To them are due our hearty thanks.

THE ENDEMIC AREA.

The endemic area is a moderate-sized subtropical city, located at the eastern end of a long, narrow island in the Gulf of Mexico, 2 or more miles distant from the mainland. Industrially the city is a seaport of considerable importance, while manufacturing is of relatively minor importance. Demographically the city differs from most southern cities in the rather small proportion of Negroes and in the large proportion of foreign-born whites, or native whites of foreign-born parentage, composing the population.

THE KNOWN INCIDENCE OF LEPROSY.

The site of the city has been settled about 100 years, but the information that we have been able to collect regarding the incidence of leprosy does not cover a period of over 30 years. This is not to be taken as a suggestion that leprosy was unknown prior to that time, but is due to the absence of any official data regarding its early occurrence.

The earliest case of leprosy of which we have been able to learn was recognized in 1886, and shortly thereafter permanently left the area.

It was apparently of local origin and is not included in our series. In 1889 Dock (1) reported two cases of local origin, which are included in our series. In a personal communication Dock states that he made at the time a "pretty thorough survey of the Mexican and Chinese quarters, but did not find any other cases." Only one Chinese case of leprosy has ever been known there, and of our series only two are Mexican. In addition to the 45 cases of our series we have learned of 25 additional cases of leprosy that have existed in this focus; but owing to the lapse of years and the absence of recorded data, we have been unable to secure many particulars and have, accordingly, omitted these cases.

Our series of 45 cases occurred during the past 30 years. We have divided these cases into three groups, as follows:

Class A: Living cases at present residing in the area (26);
Class B: Cases presumably alive, but who have removed from the area (6); and
Class C: Cases known to be dead (13).

We were able to secure the most detailed and complete information concerning the cases of class A. From an analysis of the data we have collected we present the following tables of summarization:

TABLE I.—*Summarization of cases by origin and class.*

Origin.	Class A.	Class B.	Class C.	Total.
Imported	3	2	0	5
Local cases	23	1	12	36
Unknown origin	0	3	1	4

The imported cases will be omitted from many of the subsequent tables. Where such is the case, it will be indicated in the table heading by including the number (40).

TABLE II.—*Racial incidence of cases (40).*

Race.	Class A.	Class B.	Class C.	Total.
Whites of—				
(*a*) Native-born parentage	[1] 6	1	2	9
(*b*) Foreign-born or mixed parentage	[2] 11	0	5	16
(*c*) Foreign born	[3] 1	0	3	4
Negro	[4] 5	0	2	7
Other races	0	0	0	0
Unknown	0	3	1	4

[1] 26 per cent of class A. [2] 48 per cent of class A. [3] 4 per cent of class A. [4] 22 per cent of class A.

TABLE III.—*Sex incidence of cases (40).*

Sex.	Class A.	Class B.	Class C.	Total.
Male	13	2	10	25
Female	10	2	3	15

TABLE IV.—*Age at onset of cases (40).*

Age (years).	Class A.	Class B.	Class C.	Total.
1 to 10	1	1	0	2
11 to 20	8	0	2	10
21 to 30	2	0	0	2
31 to 40	5	0	3	8
41 to 50	2	1	0	3
51 to 60	3	0	2	5
Over 61	0	0	2	2
Age unknown	2	2	4	8

TABLE V.—*Time of residence in focus before onset (40).*

Number of years.	Class A.	Class B.	Class C.	Total.
1 to 5	2	0	1	3
6 to 10	1	0	0	1
11 to 15	8	0	2	10
16 to 20	5	1	4	10
21 to 30	2	0	0	2
31 to 40	2	0	0	2
41 to 50	0	0	1	1
51 and more	1	0	1	2
Length of residence not known	2	3	4	9

From Table IV it would appear that especial susceptibility is not observed at any particular age period. In order to ascertain if length of residence within this area rather than age was an influencing factor in determining the onset, we divided our cases into two groups, according to their birthplace. The first group comprises those born within this area and the second group those born elsewhere. The individuals comprised within each of these groups were then separately classified according to length of residence and age at onset. These data are presented in Table VI. As would be expected, there is a close correlation between the length of residence and the date of onset among those born locally, the maximum correlation occurring during the second decade of life and residence. On the other hand, among those born elsewhere this correlation is not found. It is to be noted, however, that the maximum number of onsets in this group have occurred during the second decade of residence, whereas the ages of onset are among the later periods of life. It therefore appears proper to conclude that length of residence within this area rather than age is a determining factor in influencing the onset.

TABLE VI.—*Relation of age and residence to onset (40).*

Age (years).	Cases born in area.		Cases born elsewhere.	
	Length of residence.	Age at onset.	Length of residence.	Age at onset.
1 to 10	2	1	2	1
11 to 20	9	9	11	1
21 to 30	1	2	1	0
31 to 40	2	2	0	6
41 to 50	0	0	1	3
51 and over	1	1	1	6
Unknown	3	3	6	5

NOTE.—Apparent discrepancies in first and second columns are due to cases which moved away and later returned.

The patients are, or were at the time of the investigation, engaged in the following occupations:

TABLE VII.—*Occupations of patients (45).*

Occupation.	Class A.	Class B.	Class C.	Total.
Real estate agent	0	0	1	1
School child	2	0	0	2
Locomotive engineer	1	0	0	1
Laborer	10	0	4	14
Retired tailor	1	0	0	1
Delivery boy	1	0	0	1
Laundry worker	0	0	1	1
Housework	7	1	1	9
Seamstress	1	0	0	1
Sailor	0	1	0	1
Cashier	1	0	0	1
At home	1	0	0	1
Fireman	1	0	0	1
Stenographer	0	1	0	1
Harness maker	0	0	1	1
Hospital orderly	0	1	0	1
Not known	0	2	5	7

Multiple or single cases have occurred as follows:

TABLE VIII.—*Number of cases in invaded households (45).*

	Class A.	Class B.	Class C.	Total.
Households with 1 case	19	6	7	32
Households with 2 cases	2	0	3	5
Households with 3 cases	1	0	0	1
Family with 4 cases (included above)	1	0	0	1

Clinically, these cases may be grouped as follows:

TABLE IX.—*Frequency of different clinical types (45).*

Type.	Class A.	Class B.	Class C.	Total.
Tuberculous	11	2	4	17
Anesthetic	5	1	0	6
Mixed	10	2	9	21
Not known	0	1	0	1
Ulcerative (included in mixed)	1	0	0	1

The duration of these cases has been as follows:

TABLE X.—*Duration of illness in cases (45).*

Duration.	Class A.	Class B.	Class C.	Total.
Less than 1 year	2	0	0	2
From 1 to 2 years	2	0	1	3
From 1 to 3 years	5	0	0	5
From 1 to 4 years	3	0	2	5
From 1 to 5 years	3	0	1	4
From 1 to 6 years	1	0	0	1
From 1 to 7 years	3	0	1	4
From 1 to 8 years	2	0	1	3
From 1 to 9 years	0	2	0	2
From 1 to 10 years	2	0	0	2
From 1 to 15 years	2	0	0	2
From 1 to 17 years	0	0	1	1
From 1 to 24 years	0	0	1	1
Not known	1	4	5	10

In considering the data presented in this series of tables, the following facts stand out:

(1) The majority of known lepers within this city have acquired infection locally.

(2) A comparison of the racial incidence of cases with the current distribution of the population is, at the time of this writing, impossible, since the results of the 1920 census are not yet available. Furthermore, an accurate estimate for 1920 can not be made. Accordingly, we shall have to employ the 1910 population composition.

TABLE XI.—*Racial incidence of leprosy compared with racial composition of the population.*

Race.	Per cent of living lepers, 1920.	Per cent of population in 1910.
White:		
Native-born parentage	26	34.2
Native born of foreign or mixed parentage	48	27.3
Foreign born	4	16.7
Negro	22	21.7

Thus, it is apparent that cases have occurred among whites and Negroes only in proportion to their distribution in the population of this area. On the other hand, it is to be noted that the cases are more numerous among those whites of foreign-born parentage than among native-born whites. The incidence among those of German parentage seems to be proportionately higher than among those of other descent. Thus, in 1910 the native-born whites of foreign-born German parents were 2,365, or 6 per cent of the total population, whereas 35 per cent of the present cases are among their number. The significance of this is not clear. It may indicate greater susceptibility among those of German ancestry or the strain of leprosy prevalent here may be of Teutonic origin.

(3) There were 25 male and 15 female lepers.

(4) Only one of the cases developed the disease before the age of 10; yet the second decade of life contains the onsets of a larger number of cases than any subsequent age periods, none of which is exempt.

(5) For the most part infection appears to develop only after a protracted residence in this area. Only two cases are known to have developed the disease under five years of residence. Most of the cases have appeared following a period of residence of from 11 to 20 years. It appears that the length of residence is a more important factor in determining the age of onset than is the age itself.

(6) Among males the greatest incidence is among laborers. The occupational incidence among females is not suggestive. In general, the occupational incidence coincides with the social status of the cases—that is, cases are most prevalent among those in the humbler walks of life.

(7) The disease in this focus tends to run a chronic course, characteristic of its occurrence elsewhere. The tuberculous type is more common than the anesthetic, and the mixed is more frequent than either of the others. Only one of the present cases has any ulcerations.

ANNUAL INCIDENCE.

The annual incidence of leprosy within recent years is shown in the following table:

TABLE XII.—*Annual incidence of leprosy.*

Year.	Population (mid year).	Onset.		Cases reported.	Death rate per 100,000.
		Number.	Rate per 100,000.		
1911	37,851	0	0	1	0
1912	38,597	2	5.2	2	2.6
1913	39,343	2	5.1	2	2.5
1914	40,089	1	2.5	0	2.5
1915	40,835	1	2.4	0	0
1916	41,581	4	9.6	0	4.8
1917	42,327	4	9.4	0	0
1918	43,073	2	4.7	8	0
1919	43,819	1	2.3	3	4.5
1920 [1]	44,565	1	2.2	1	2.2

[1] June 1.

While our information concerning the incidence of leprosy prior to 1910 is meager, and in all probability the majority of cases are unrecorded, yet it is uncertain that the incidence of the disease has increased materially during the last decade. An idea of the recent comparative incidence of leprosy in this focus and other foci of the disease is given in the following table:

TABLE XIII.—*Comparative incidence of leprosy in several foci.*

Locality.	Number of cases known living in focus.	Cases reported during year.
Local focus (1918) (own data)	26	8
State of Texas (1918) [1]	18	0
New York City (1918) [1]	23	2
San Francisco (1918) [1]	19	7
State of Minnesota (1918) [1]	10	2
United States (continental) (1918) [1]	209	63

[1] Data from Annual Report of the Surgeon General, United States Public Health Service, 1919.

From our study we feel confident that there are still a number of unrecognized cases of leprosy living in this focus, yet the foregoing comparison calls attention to the inadequacy of our knowledge of the incidence of the disease in the United States as a whole, particularly when we note the number reported from the entire State of Texas compared with the number known in this focus (which is in Texas) during

the same year. Even considering the notorious inadequacy of our knowledge of the prevalence of leprosy in the United States, it seems possible that the actual incidence of the disease in this focus is greater than in most, if not all other, of those areas in the United States where the disease is known to be endemic.

GEOGRAPHICAL DISTRIBUTION OVER THE ENDEMIC AREA.

The city under consideration is divided into 13 precincts. The density of population in each precinct and the incidence of leprosy therein are shown in Table XIV.

TABLE XIV.—*Density of population and leprosy incidence.*

Precinct.	Population, 1910.	Density per acre.	Leper population, 1920.	Lepers originating in each area.	Cases of German descent.
1	2,943	22	1	6	3
2	2,810	31	1	2	0
3	2,425	23	1	1	0
4	2,505	24	3	1	2
5	3,228	31	0	1	0
6	4,553	6	8	6	4
7	3,960	2	5	7	1
7½	2,615	12	1	2	0
8	2,609	13	0	0	0
9	2,408	12	0	0	0
10	2,515	17	4	6	4
11	2,352	16	0	0	0
12	1,998	19	2	3	0

It is to be noted that in three precincts we have no record of either past or present cases of leprosy originating therein. It is also to be noted that the distribution of these cases is not proportional to the density of population, and that we can further distinguish several well-defined local foci of infection, where a circle with a radius of two or three blocks will circumscribe all the cases in that area. Thus we can note one such focus in the first and second precincts; another in the sixth, one which lies in both the sixth and seventh precincts; one in the tenth precinct, and another in the twelfth precinct. It is also to be noted that the focus in the first and second precinct has very nearly become extinct, the majority of the cases having either died or moved away, while those still remaining are of several years duration. The focus which lies in both the sixth and seventh precinct appears quiescent, for no new cases have been reported within this area for several years. The westerly focus in the sixth precinct, the focus in the tenth, and the focus in the twelfth precincts appear to be active at present and have contributed the cases recognized within the last two years.

Referring to the high incidence of the disease among persons of German birth or descent, and noting the place of their residence, it is found that most of these cases are concentrated in the first, sixth,

and tenth precincts. This suggests that there may have existed a degree of social contact among these cases, despite negative histories of contact given to us in reply to interrogations.

DATA RELATING TO ROUTE OF INFECTION.

We have already stated that of the households in which at present are living cases, 19 have one case; 2 two cases; and 1 three cases. In addition, surveying all of the past or present cases known to us, we were able to secure the following data relative to known association with a case of leprosy prior to the onset.

TABLE XV—*History of contact with lepers prior to onset (45).*

History of contact.	Class A.	Class B.	Class C.	Total.
Known association with a leper at—				
Home	7	0	1	8
Elsewhere	6	1	3	10
Contact not known	10	1	1	12
No data secured	3	4	8	15

In 30 cases we were able to secure definite information upon this point. Eighteen of these, or 60 per cent, gave a history of such association prior to the development of their own illness.

Contact with preexisting cases of leprosy took place under the following circumstances:

Case 5 conducted a rooming and boarding house in which case 30 lived for three months, one year prior to the onset of case 5.

Case 8 went on frequent fishing trips with case 25.

Case 9 slept with case 48 for a period of two months, 10 years prior to her own onset.

Case 10 associated with a leprous brother-in-law and niece in Mexico.

Case 11 is in contact with her mother, case 43, whose illness was diagnosed as pellagra.

Case 12, as a boy, played with cases 37 and 46.

Case 13, contact with mother, case 14.

Case 14, contact with husband, who did not reside in this city.

Case 15, contact with mother, case 11. In this family there are three generations of leprosy cases.

Cases 17 and 18 are two brothers, whose onsets were practically simultaneous. Contact with mother, case 19.

Case 21. A granddaughter of case 19 and a niece of cases 17 and 18. This is a second instance of three generations of leprosy patients in one family.

Case 25 was, as a child, associated with cases 17 and 18.

Case 40 is a brother of case 48.

Case 41 was in contact with his mother, who probably contracted infection while living in Mexico.

Case 46, slept with his older brother, case 37.

It might be possible that the tuberculous and anesthetic types of leprosy are due to separate strains of the bacillus, each having a different selective localization in the body. If this is the case, it might also be possible that the histories of contact would show that the strain breeds true, i. e., tuberculous cases of leprosy give rise to tuberculous cases, providing the known leprous associates were the actual source from whom infection was secured.

Data bearing upon this point are presented in the following table:

TABLE XVI.—*Type of case with whom living cases were in contact (26).*

Living cases giving a history of contact.			Living cases not giving a history of contact.
Clinical type.	Number of cases.	Contact known with—	
1. Tuberculous	4	4 tuberculous lepers	7 cases.
2. Anesthetic	2	1 mixed leper	3 cases.
		1 anesthetic leper	
3. Mixed	7	3 tuberculous lepers	3 cases.
		1 anesthetic leper	
		1 mixed leper	
		1, type unknown	
		1, to both simple types	

From these data it would appear that if these cases do owe their origin to contact transmission from cases with whom they are known to have been in contact, the clinical types of leprosy are possibly due to the selective preference of different strains of leprosy for either the subcutaneous or nervous tissues, which strains tend to maintain this behavior on transfer.

In view of the inadequacy of our data to entirely explain the grouping of the cases into several small foci on the basis of contact transfer, it may be worth while to consider other possible means of transfer. The only other routes of transmission, with which we are familiar, that would produce a similar epidemiological picture, are those through insects. (1) From the short radius of these foci it would appear that the assumed insect has a very narrow radius of activity; and (2) from the relatively few cases that develop in a focus, it would seem that the insect is not a very efficient means for the conveyance of the organisms. So far as the local insect fauna is concerned, there are three species that command our attention in this connection, namely, *Musca domestica*, *Aedes calopus* (*Stegomyia fasciata*), and *Cimex lectularius*.

That leprosy bacilli can possibly be conveyed by insects, especially those which suck blood, would appear possible from the following facts:

(1) The leprosy bacilli are present in the subcutaneous tissues of patients at a depth where they could be reached by the proboscis of a blood-sucking insect, or are present in the discharges from ulcerations.

(2) The localization of our cases is suggestive of the activity of known species having a narrow radius of activity. The three species mentioned tend to have such a narrow radius.

Against this view may be advanced the following facts:

(1) The known infections transmitted through the activity of these insects tend to spread more rapidly with a higher incidence than leprosy, even making allowance for the fact that the former are acute infections, while leprosy is chronic.

(2) The known observations upon the presence of leprosy bacilli in insects have given very few positive results. Currie (2) has reviewed the data available upon this point up to 1910 and has submitted some negative data secured by himself regarding mosquitoes. Brinckerhoff (3), Leboeuf (5), and Noc (6) report largely negative observation on mosquitoes, while Thomson (4), Leboeuf (5), and Skelton and Parham (7) report negative results with bedbugs. McCoy and Clegg (8) report positive findings from two head lice captured on a leper. Leboeuf (9) found 19 of 23 house flies fed upon ulcers to be positive, while Honeij and Parker (10) found leprosy bacilli in both the house fly and the stable fly. It is therefore apparent that the idea of insect transmission has little evidence to support it, with the exception of that concerning the house fly. We have previously noted that only one of our present cases is ulcerative. We are therefore forced to conclude that the idea of insect transmission is inadequate to explain the peculiar grouping of our cases.

RAT LEPROSY.

In this connection we made some effort to detect rat leprosy in the course of the examination of some 23,000 rats for plague. Only 7 leprous rats were identified, as proved by the detection of acid-fast bacilli in smears. These were all Norways. In the course of the search, 14,000 Norway rats were examined. These leprous rats were secured from precincts 6, 7, 8, and 9. Special effort to secure additional leprous rats from these areas was made without success.

RELATION OF FISH DIET TO LEPROSY INCIDENCE.

Some years ago considerable attention was drawn to the consumption of fish in relation to the incidence of leprosy. We secured the

following data regarding the consumption of fish from our series of cases:

TABLE XVII.—*Consumption of fish by leprous patients (45).*

Fish frequently eaten	11
Fish occasionally eaten	1
Fish rarely eaten	9
Fish never eaten	2
No data	22

This does not appear to support the view that a fish diet bears any relationship to the development of the disease.

CONCLUSIONS.

From the foregoing data, which we have collected, we draw the following conclusions:

(1) The majority of the known cases of leprosy in this focus have acquired infection locally.

(2) There is apparently a greater incidence of the disease among persons native born of foreign-born German parents than among any other group in the population.

(3) There is a preponderance of cases among males.

(4) More cases have developed during the second decade of life than in any other age period, though no age group appears to be immune.

(5) The length of residence within the area appears to be a more important factor than age in determining the onset. The majority of cases develop the disease during the second decade of residence.

(6) It is uncertain whether the area of incidence of the disease is undergoing any increase.

(7) In proportion to the population of the area, there is probably a higher incidence of leprosy in the area studied than elsewhere in continental United States.

(8) The cases within the area are grouped into several distinct foci.

(9) A major proportion of the cases give a history of contact or association with a case of leprosy prior to the onset of their own infection. Known contact transfer will not explain the origin of all the cases or the peculiar grouping into foci of a small radius.

(10) The hypothesis of insect transmission is inadequate to explain the grouping of the cases. More likely, contact with unrecognized cases or unrecognized contact with known lepers is responsible for the 40 per cent of cases from whom a contact history was unobtainable.

In concluding, we should call attention to the fact that absolutely no official control or supervision in any form has ever been exercised over the cases of leprosy within this area.

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THE NOTIFIABLE DISEASES.

PREVALENCE DURING 1919 IN CITIES OF OVER 100,000.[1]

ANTHRAX, GONORRHEA, INFLUENZA, MALARIA, PNEUMONIA (ALL FORMS), RABIES IN ANIMALS, RABIES IN MAN, SYPHILIS, TUBERCULOSIS (ALL FORMS AND PULMONARY), CEREBROSPINAL MENINGITIS, DIPHTHERIA, MEASLES, PELLAGRA, POLIOMYELITIS (INFANTILE PARALYSIS), SCARLET FEVER, SMALLPOX, AND TYPHOID FEVER—CASES AND DEATHS REPORTED, 1919; INDICATED CASE AND DEATH RATES PER 1,000 POPULATION; FATALITY RATES PER 100 CASES; AND AVERAGE NUMBER OF CASES REPORTED DURING PRECEDING YEARS.

The following tables were compiled from data furnished by the city health officers. They include all cities in the United States of 100,000 population or over, although one city furnished mortality data only.

The populations given and which were used in computing the rates were estimated as of July 1, 1919, from the preliminary reports of the census of January 1, 1920, and the reports of the census of April 15, 1910. The figures given probably differ somewhat from estimates which will be made later, which will be based on the final reports of the 1920 census and will take into consideration changes in area of the cities between 1910 and 1920, data for which are not now available. The differences, however, will probably not be such as to seriously affect the rates given in the tables.

Averages of the total cases reported annually during the years 1914–1918 were made for cerebrospinal meningitis, diphtheria, measles, scarlet fever, smallpox, and typhoid fever by adding the numbers of cases and dividing the sum by the number of years for which data are available. For pellagra the data were available only for the years 1915 to 1918, inclusive. In compiling the data relative

[1] It will be noted that some of the cities are apparently much more successful in obtaining reports of the notifiable diseases than are others. This may be due to the greater activity of their health departments or to a greater interest in the public welfare on the part of their practicing physicians. That the health departments of certain cities are securing fairly complete information of the prevalence of preventable diseases is indicated in a number of instances by the large numbers of cases reported as compared with the numbers of deaths registered from the same causes.